

WESTERN ANADROMOUS FISH HABITAT PROGRAM PLAN, 1986-1990



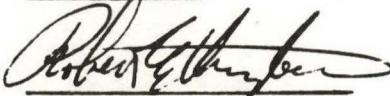
June 1986

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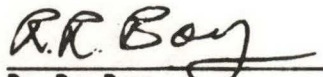
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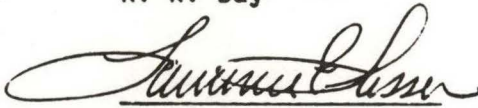
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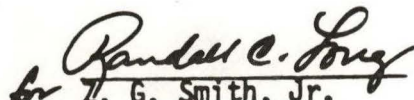
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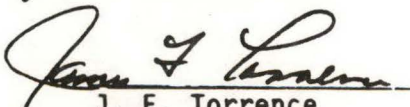
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WESTERN ANADROMOUS FISH HABITAT

PROGRAM PLAN, 1986-1990

EXECUTIVE SUMMARY

INTRODUCTION

Western lands administered by the USDA Forest Service contain many valuable natural resources, including prominent and highly valuable anadromous fisheries. Land management activities by the Forest Service directly affect most of the anadromous fishery resources of the west, since most streams used by these fish originate on the National Forests.

Recognizing the biological, economic, and social significance of western anadromous fisheries, and the responsibility for maintaining viable habitat for these fish, the USDA Forest Service initiated an integrated Western Anadromous Fish Habitat Program in 1975. Scientists, managers, and administrators from three Research Experiment Stations, five National Forest System Regions, and the Washington, D.C., Office are active participants in the coordinated westwide program. Many state and federal agencies and several universities are also directly involved. The program represents a unique "partnership for accomplishment" between Forest Service research and management, and cooperators.

The objective of the program is to maintain and restore productive habitat for anadromous fish in coordination with the overall scheme of management activities occurring on the National Forests.

THE RESOURCE

Eight major species of anadromous salmonids are distributed along the west coast of North America from northern California to Alaska, and inland into Idaho. These migratory species require two primary habitats: freshwater streams and the Pacific Ocean. In general, the complex environmental conditions required by all species of anadromous salmonids are similar, and their availability greatly influences the success and abundance of the fish. Three general types of freshwater habitat are important: spawning habitats, rearing habitats, and migration habitats.

Anadromous salmonids of the Pacific Coast support commercial, sport, and subsistence fisheries. Harvests along the west coast of the United States have recently averaged more than 75 million fish per year, exceeding those of other nations bordering on the north Pacific Ocean.

The salmon fishery is one of the three most valuable marine commercial fisheries in the United States, based on gross market value. In recent years, commercial salmon fishing has grossed about \$300 million to \$400 million annually.

Recreational fishing expanded during the past two decades to become a major user of the salmon resource in certain areas--particularly in Puget Sound, the southern part of the Washington coast and the Columbia River mouth, and the northern Oregon coast.

The habitat of anadromous salmonids is vulnerable to a variety of environmental changes. Alteration of watershed characteristics that directly affect water quantity and quality, or indirectly affect aquatic habitat, will affect fisheries productivity. Logging, road construction, livestock grazing, mining, water development projects, urbanization, agriculture, and recreation can all create conflicts that affect the quality of anadromous fish habitat.

These potential conflicts between land management and maintenance of productive anadromous fish habitat can only be resolved through a coordinated research and management effort, such as the Western Anadromous Fish Habitat Program.

PROGRAM OVERVIEW

National Forest System.--The National Forest System is responsible for maintaining and enhancing habitat on the National Forests to support the freshwater phase of salmonid life histories. The federal government also recognizes trust responsibilities for the fishing rights of certain tribes of native Americans. These responsibilities require that habitats be maintained in a productive condition.

Forest Service Research.--Forest Service Research Stations and their cooperators investigate all phases of the fresh water portion of the life cycles of anadromous salmonids, including the watersheds and aquatic communities they occupy. Research, both basic and applied, is designed to increase the basic understanding of aquatic ecosystems, develop new

techniques for enhancing and monitoring fish habitats and biological communities, and provide practical methods for coordinating watershed and fisheries management goals.

Organization and Planning.--In 1975, USDA Forest Service scientists, managers, and administrators of the Western Program developed a plan for anadromous fish habitat research and management. A document entitled "Proposed Anadromous Fish Habitat Program for the Western United States" (October, 1975) became the plan for USDA Forest Service anadromous fish habitat research during the period 1976-1980. Another plan was subsequently developed to guide anadromous fish habitat research during the period 1981-1985.

An important aspect of the Western Anadromous Fish Habitat Program is cooperation with other agencies and institutions as well as between the Research and the National Forest System branches of the USDA Forest Service. A significant portion of the Program's research funding is used to support extramural research.

PROGRAM ELEMENTS

Accomplishments to Date

National Forest System.--Accomplishments fall into two categories, applications and development.

A. Applications.--Fisheries management support to other Forest activities such as timber harvest, road building, and range and energy development is an important element of the National Forest System program.

B. Development.--Development activities from 1980-1985 were focused in four major areas.

1. Land/Aquatic Classification and Channel Typing.
2. Inventory Methods.
3. Fish Habitat Relationships Models.
4. Monitoring.

Research.--Anadromous fish habitat research is conducted in three Research Work Units at four major locations--Juneau, Alaska; Corvallis, Oregon; Arcata, California; and Boise, Idaho.

During the last 5 years, significant progress has been made in understanding the functional relationships fish have with their stream environment and impacts of land use on fish habitat. Major efforts were made to provide newly acquired technology to planners and managers, even before formal results were published. Work during 1981-1985 has produced more than 130 publications in scientific journals, Forest Service and other agency technical papers, symposium proceedings, and other outlets.

PLANS FOR THE FUTURE (1986-1990)

Application

During the next five years, the National Forest System will continue to emphasize cost-effective anadromous fish habitat improvement and a high level of resource coordination in support of the National Forest System goal to improve habitat carrying capacity of anadromous salmonids. The result will be increased production of anadromous fish for commercial and sport fishing, Native American subsistence and ceremonial use, and compensation for losses from other resource development activities.

Development

Emphasis during the 1986-1990 period will shift from National development to Regional programs incorporating identifiable goals, measureable objectives, schedules for action, and links to the budgeting process. At present, there is a need for accomplishment accountability at all administrative levels. Greater management emphasis, a more active leadership role by Regional Fish and Wildlife Directors, and better links to research will be critical to the success of the development program.

Much of the planned work is directly related to the National Forest System Fish Habitat Relationships Program and its links with research. The funding needed in the anadromous fish Regions to accomplish these and ongoing tasks is as follows:

	Years				
	1986	1987	1988	1989	1990
Dollars (M)*	402	445	445	445	445

*(Combined for Regions 1, 4, 5, 6, and 10.)

Research

Unmet needs.--There are many unmet needs for research to address during the next five years. The highest priority subject areas are listed below.

- A. Habitat Requirements and Limiting Factors.
- B. Natural Processes.
- C. Land-use Relationships and Effects.
- D. Habitat Enhancement.
- E. Inventory and Classification.

Current Program Plan.--Table 1 displays a summary of the plans for the current program, and an expanded program, by annual funding in each of several research components.

Table 1. Western Anadromous Fish Program research plans for 1986-1990 showing needed annual appropriation levels of funding (\$1,000) to address research plan components at the current and expanded program levels.

Research Component	Current Program Plan	Expanded program funding priorities	
		1	2
Habitat Requirements and Limiting Factors:	327	547	597
Natural Processes:	88	238	238
Inventory and Classification	40	160	235
Land-use Relationships and Effects	285	555	674
Habitat Enhancement:	187	327	400
Economic Analysis:	87	87	120
Program Total	1014	1914	2264

Expanded Program Plan.--The expanded program, given at two alternative levels of funding (Table 1), is consistent with the Forest Service national program plan documented in "Meeting the Challenges--A Program in Wildlife and Fish Habitat Research" (prepared by Forest Environment Research, USDA Forest Service, December 1, 1984).

This third 5-year plan of the Western Anadromous Fish Habitat Program will help guide research, development, and management of anadromous fish habitat in the western United States during the period 1986-1990.

WESTERN ANADROMOUS FISH HABITAT
PROGRAM PLAN, 1986 - 1990

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Common and scientific names of fish referred to in the plan.

Common name	Scientific name
Pink salmon	<u>Oncorhynchus gorbuscha</u> (Walbaum)
Chum salmon	<u>Oncorhynchus keta</u> (Walbaum)
Coho salmon	<u>Oncorhynchus kisutch</u> (Walbaum)
Sockeye salmon (kokanee)	<u>Oncorhynchus nerka</u> (Walbaum)
Chinook salmon	<u>Oncorhynchus tshawytscha</u> (Walbaum)
Cutthroat trout (searun)	<u>Salmo clarki</u> Richardson
Rainbow trout (steelhead)	<u>Salmo gairdneri</u> Richardson
Dolly Varden	<u>Salvelinus malma</u> (Walbaum)
Redside shiner	<u>Richardsonius balteatus</u> (Richardson)

WESTERN ANADROMOUS FISH HABITAT
PROGRAM PLAN, 1986-1990

INTRODUCTION

Western lands administered by the USDA Forest Service contain many valuable natural resources, including prominent and highly valuable anadromous fisheries. Anadromous salmonids depend on clean cool streams and rivers that emanate from forested mountainous watersheds for reproduction and rearing. Land management activities by the Forest Service directly affect most of the anadromous fishery resources of the west, since most streams used by these fish originate on the National Forests.

The characteristics of anadromous fish resources of Washington, Idaho, Oregon, and California have changed significantly over nearly a century of resource exploitation. Over the years, size of catches and size of fish have both declined. Excessive harvest of fish and destruction of habitat resulting from human activities have produced a double jeopardy that has dramatically reduced yields. Alaskan stocks have fared better, declining earlier in the century but showing a remarkable recovery in recent years.

Recognizing the biological, economic, and social significance of western anadromous fisheries, and the responsibility for maintaining viable habitat for these fish, the USDA Forest Service initiated an integrated Western Anadromous Fish Habitat Program in 1975. Scientists, managers, and administrators from three Research Experiment Stations,

five National Forest System Regions, and the Washington, D.C., Office are active participants in the coordinated westwide program. Many state and federal agencies and several universities are also directly involved. The program represents a unique "partnership for accomplishment" between Forest Service research and management, and cooperators.

The objective of the program is to maintain and restore productive habitat for anadromous fish in coordination with the overall scheme of management activities occurring on the National Forests. Land management activities throughout the Pacific Northwest and Alaska have the potential to significantly alter the habitat of anadromous salmonids. Research has shown that logging and road construction often have negative effects on spawning, rearing, and migration habitat of salmonids, but the effects can be neutral or positive in some cases. The range of effects is linked to the type of management activity and the geomorphology, soils, climate, and vegetation of the affected watersheds. Interrelationships between these variables and fish habitat quality are not thoroughly understood, and ability to integrate these variables and predict management effects needs to be refined. This holds true for livestock grazing and mining activities as well as for timber management.

Research can clarify these complex relationships by establishing the ecological linkage between anadromous fish, habitats, watersheds, and human activities. Once this knowledge is in hand, fish habitats can be protected while land management activities proceed, and previously damaged habitats can be rehabilitated or enhanced in the most efficient manner.

Protection and maintenance of high quality fish habitat and restoration of degraded habitat are the goals of fishery and fish habitat managers. In some cases, however, production of anadromous salmonids may be limited by reduced quality of their spawning and/or rearing areas, or by blocked access to migrating fish. The factors limiting production in these streams may be the result of poor resource management practices in the past, or the result of natural processes. With the existing knowledge of habitat requirements of anadromous salmonids, it is possible to undertake some fish habitat improvement programs with successful results. Very often, however, these habitat improvement programs are not based on sufficient knowledge of the fish's needs or the factors limiting their production in a given situation. The result is often inefficient utilization of funds that have been allocated for this purpose.

THE RESOURCE

Species, Distribution, and Life History

Anadromous salmonids are distributed along the west coast of North American from northern California to Alaska, and inland into Idaho (fig. 1).

Eight major species of anadromous salmonids are produced in this region: five salmon--chinook (king), coho (silver), sockeye (red), chum (dog), and pink (humpback); two trout--steelhead and cutthroat; and one char--Dolly Varden. Most species live 2 to 6 years. In that time, some fish can attain a weight of 30 pounds or more.

These migratory species have evolved a complex reproductive process that requires two primary habitats: freshwater streams and the Pacific Ocean (fig. 2). The spatial and temporal habitat needs of species vary considerably, and even vary by races within a given species, so the life history of each group is unique and complex.

Anadromous fish generally reproduce in streams flowing from forested watersheds, spend the first part of their life in fresh water streams or lakes, then migrate to the ocean where they mature to adulthood. When they return to fresh water to spawn, a strong homing instinct leads them back to the stream of their origin, sometimes to the same spawning riffle where they began their life.

In general, the environmental conditions required by all species of anadromous salmonids are similar and greatly influence the success and

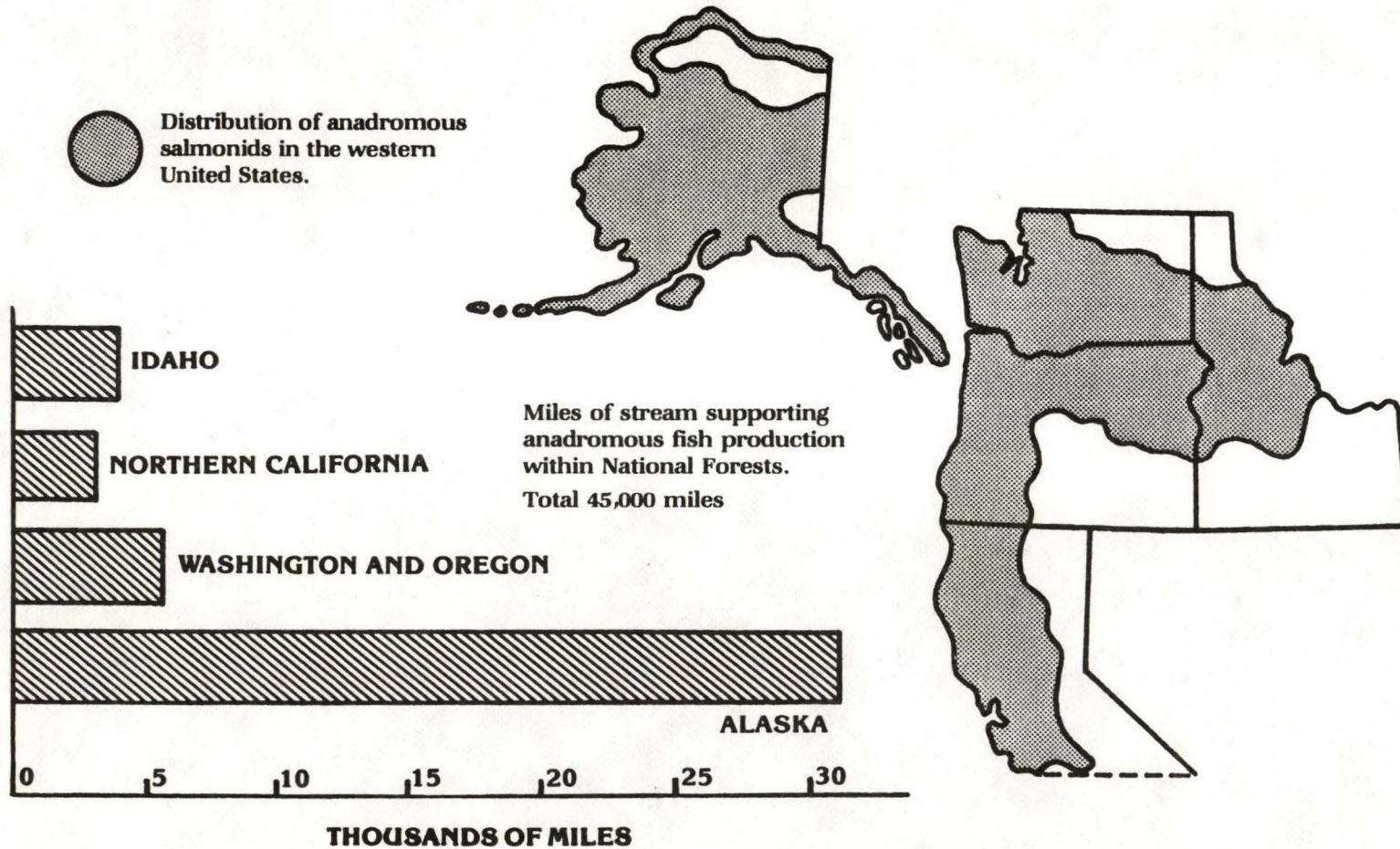


Figure 1. Distribution of anadromous salmonids in the western United States.

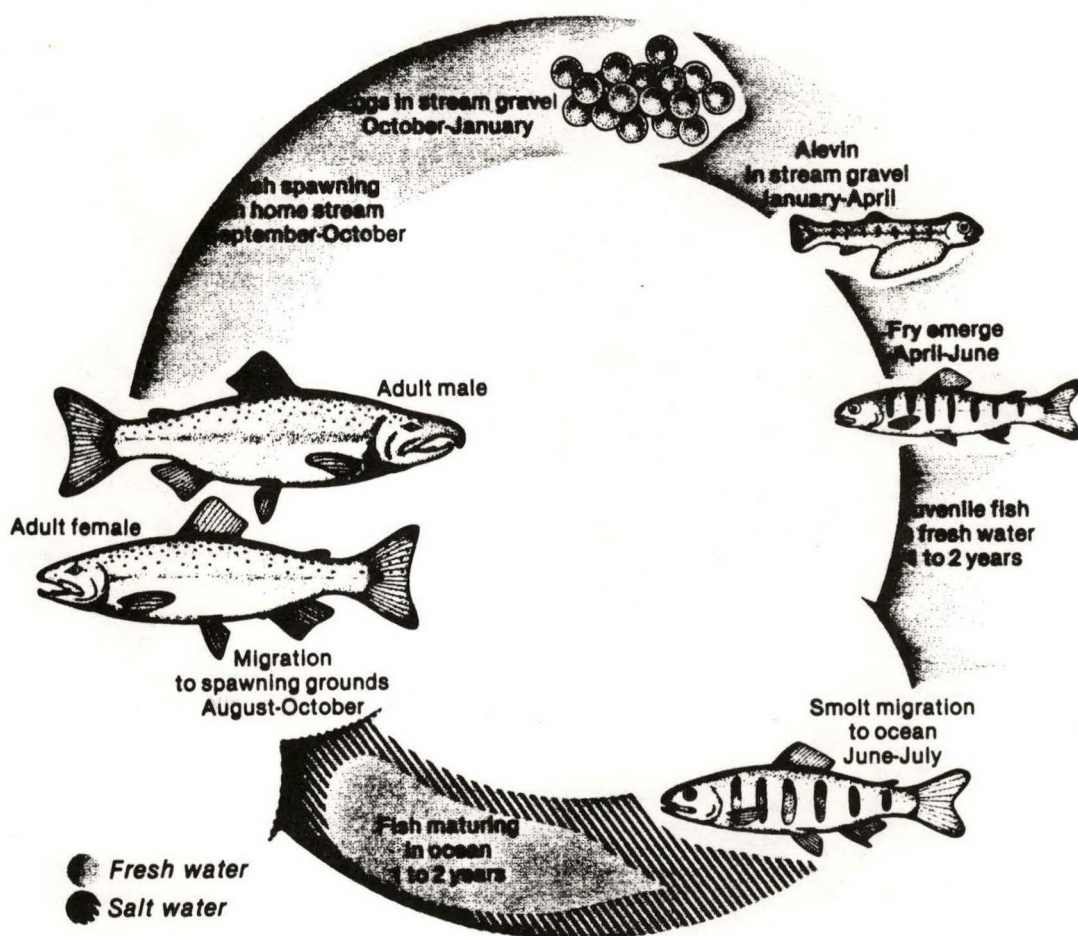


Figure 2. Typical life cycle of anadromous salmonids.

abundance of the fish. Three general types of freshwater habitat are important:

1. Spawning habitats where the adult fish deposit eggs, embryos incubate, and fry emerge.
2. Rearing habitats where the young fish feed and grow until they are ready to begin their downstream migration to the sea.
3. Migration habitats that the young fish use to reach the ocean and the adults use to return from the sea to the spawning areas.

When specific requirements of these habitats are not met, fish production declines.

Fisheries

Stocks of anadromous salmonids along the Pacific Coast support commercial, sport, and subsistence fisheries. Commercial salmon catches of the United States exceed those of other nations bordering on the north Pacific Ocean. Harvests along the west coast of the United States have recently averaged more than 75 million fish per year (Table 1). Several types of gear are used in commercial fisheries. Purse-seine and gill-net fisheries occur in protected waters such as Puget Sound, the Columbia River, and the inside waters of Southeast Alaska. Commercial trolling dominates the ocean fishery in California, Oregon, and Washington. Trolling is significant in southeastern Alaska as well.

Commercial salmon fisheries consist of many independent operations with no more than a few crew members. Many trollers and gill-netters are

Table 1. Average annual United States salmon catches, 1976-1980.

	Sockeye	Chum	Pink	Coho	Chinook	Total
	Thousands of fish					
Alaska	21,097	7,340	37,106	2,478	676	68,697
Washington	1,363	712	1,337	1,883	633	5,928
Oregon	--	6	25	896	333	1,260
California	--	--	1	238	552	791
Total:	22,460	8,058	38,469	5,495	2,194	76,676

operated by only one or two persons. Nevertheless, about 33,000 workers fish commercially at least part time in United States salmon fisheries, using 20,000 vessels.

In recent years, commercial salmon fishing has grossed about \$300 million to \$400 million (Table 2). The finished products (mostly canned pack, cured, and fresh or frozen filets and steaks) have a market value of about \$1 billion wholesale. Of this \$1 billion in wholesale value, about \$20 million to \$40 million comes from salmon produced in Oregon, Washington, Idaho, and California.

The salmon fishery is one of the three most valuable marine commercial fisheries in the United States, based on gross market value. Much of the increase in salmon market values since the early 1950's was caused by increased prices. The average ex-vessel price rose from \$0.13/lb in 1950-1954, to \$0.67/lb in 1975-1980. In recent years, above average runs of Alaska sockeye and pink salmon have caused a moderate drop in ex-vessel prices. The average ex-vessel price was \$0.57 lb in 1984.

Table 2. U.S. commercial landings of Pacific salmon by species and total ex-vessel values, 1950-1982.

Years(s)	Landings						Ex-vessel value
	Sockeye	Pink	Chum	Coho	Chinook	Total	
	- - - - - Millions of pounds - - - - -						\$ Millions
1950-54	89.6	101.9	73.8	38.5	39.2	343.0	43.4
1955-59	68.1	93.9	51.6	24.4	32.9	270.9	41.7
1960-64	71.5	124.7	52.6	26.2	26.4	301.4	51.6
1965-69	90.3	111.0	41.7	34.9	27.3	305.2	63.3
1970-74	82.4	69.0	52.4	36.0	29.9	269.7	97.2
1975-79	103.0	140.5	48.0	33.6	32.3	357.4	240.4
1980	207.6	253.5	84.9	39.3	28.5	613.8	352.4
1981	226.2	257.1	98.9	35.2	31.1	648.5	438.2
1982	221.2	221.5	92.0	59.2	34.6	607.5	392.0
1983	310.1	194.1	79.9	30.7	24.4	639.2	350.9
1984	229.7	275.6	113.3	51.1	21.7	691.2	391.5

Recreational fishing expanded during the past two decades to become a major user of the salmon resource in certain areas--particularly in Puget Sound, the southern part of the Washington coast and the Columbia River mouth, and the northern Oregon coast. State records indicate annual sport salmon harvests nearly doubled from an average of 546,000 fish per year in 1950-1954, to 1,018,000 fish in 1976-1980. Although the sport harvest does not rival the commercial harvest, major portions of the coho and chinook salmon catches are taken by recreational hook-and-line, and almost all of the steelhead are taken by recreational anglers.

The net economic value for salmon and steelhead angling is estimated to be \$83 million in Washington, Oregon, and California, \$7 million in Idaho, and \$36 million in Alaska.

Pacific coast salmon and steelhead stocks are also used for subsistence, cultural, and religious purposes by native Americans. The numbers and pounds of fish used for these purposes are unknown at the present time.

Fish Habitat and Land Management

The habitat of anadromous salmonids is vulnerable to a variety of environmental changes. Alteration of watershed characteristics that directly affect water quantity and quality, or indirectly affect aquatic habitat, will affect fisheries productivity. Logging, road construction, livestock grazing, mining, water development projects, urbanization, agriculture, and recreation can all affect the quality of anadromous fish habitat.

Streamside or "riparian" vegetation strongly influences the quality of habitat for anadromous fish. It provides shade and prevents extreme changes in water temperatures. Roots of trees and shrubs help to stabilize streambanks and provide cover in the form of overhanging banks.

Riparian vegetation helps to prevent sediment from entering streams and provides organic material that forms the base of the food chain for aquatic insects and fish. The addition of large pieces of wood, such as whole trees fallen across or into streams, provides cover and helps to

create and maintain pools. Removal of streamside vegetation by logging, road construction, and other activities can reduce the quality of fish habitat.

Sediment enters streams through natural processes such as landslides and erosion. Human activities can, and often do, accelerate these processes. For example, road construction associated with logging has a high potential for adding sediment to stream channels. When too much fine sediment enters a stream, habitats for both spawning and rearing suffer.

The most prominent land-use activities in the western United States that affect anadromous fish habitat, excluding dams for irrigation and hydropower, are timber harvesting and livestock grazing. Timber harvesting in western forests is commonly accomplished by clearcutting; that is, all the timber in a given area is cut. The size of clearcutting units has decreased over the years as problems associated with large clearcuts have been identified. For example, in southeast Alaska it was not uncommon in the 1950's and 1960's for individual clearcuts to range from several hundred to more than a thousand acres. Today, individual clearcuts on National Forests are generally limited to less than 100 acres.

In the early days of clearcutting, trees were often cut to the banks of streams, leaving the streams with no canopy or streamside vegetation. Today, with effective legislation such as the National Forest Management Act, buffer strips varying in width from a few feet to several hundred feet usually are left along streambanks. Buffer strips have the

potential for windthrow during severe windstorms, but the effects of windthrow on habitat of anadromous salmonids are not necessarily adverse. Habitat can be improved by the addition of windthrown trees.

Livestock regularly use valley bottoms adjacent to streams for grazing and resting. Unrestricted livestock use along streams can result in overgrazing of riparian vegetation. This in turn can cause increased water runoff and soil erosion, and ultimately an increase in sediment deposition in stream channels. Destruction of the streambanks by trampling can cause the loss of undercut banks, a prime rearing habitat of anadromous salmonids, and increased sediment in gravels used for spawning.

Various grazing systems have been used in recent years to control livestock use in streamside areas. The effectiveness of alternative systems in protecting stream habitat is yet to be demonstrated. The best method of protecting fish habitat is to exclude livestock from the streamside zone and provide alternate sources of water, such as stock ponds, within the pastures. Cost of fencing, however, is high and can be prohibitive. An additional cost of this approach is the production and income foregone when livestock are not allowed to graze in the riparian zone.

These potential conflicts between land management and maintenance of productive anadromous fish habitat can only be resolved through a coordinated research and management effort, such as the Western Anadromous Fish Habitat Program.

PROGRAM OVERVIEW

Role and Responsibility of the Forest Service

National Forest System.--The National Forest System is responsible for maintaining and enhancing habitat on the National Forests to support the freshwater phase of salmonid life histories. The federal government also recognizes trust responsibilities for the fishing rights of certain tribes of native Americans. These responsibilities require that habitats be maintained in a productive condition. Anadromous salmonids use some 45,000 miles of streams on the National Forests for rearing, spawning, and migration. USDA Forest Service management activities on these streams cover three basic areas: (1) restoration, (2) maintenance, and (3) enhancement.

A. Restoration.--Past land use activities have damaged some salmonid habitat and efforts are being directed to offset these impacts. Stream surveys are being conducted to identify damaged habitat and plan for it's restoration. Improving riparian habitat is a priority mitigation effort.

B. Maintenance.--Coordinating fish habitat management with other resource activities is an important responsibility of National Forest System resource managers. Increased support can be provided to minimize the impacts of land use activities on fish habitat.

C. Enhancement.--Fish habitat biologists estimate up to a 60 percent increase in habitat capability can be accomplished within the National Forests. Maintaining a strong program of improving anadromous fish

access to new spawning and rearing habitat through instream barrier removal, creating habitat with instream structures and debris manipulation, and creating spawning and incubation channels can help achieve this increase. All projects are fully coordinated with the respective State Fish and Game agencies.

Beginning in 1983, anadromous fish habitat management became a separate budget line item for the National Forest System, and therefore is easily identified in planning and output accomplishments. Funding for enhancement opportunities on National Forests increased slowly during the last decade, but accelerated during the past 3 years. In addition, 3-4 million dollars are spent annually by the National Forest System to coordinate fish habitat protection with management activities.

Forest Service Research.--Forest Service Research Stations and their cooperators investigate all phases of the fresh water portion of the life cycles of anadromous salmonids, including the watersheds and aquatic communities they occupy. Research, both basic and applied, is designed to increase the basic understanding of aquatic ecosystems, develop new techniques for enhancing and monitoring fish habitats and biological communities, and provide practical methods for coordinating watershed and fisheries management goals.

The present Western Anadromous Fish Habitat Program is addressing three major aspects of anadromous fish habitat: (1) habitat requirements of anadromous salmonids; (2) effects of natural watershed processes and land management activities on anadromous fish habitat; and (3) rehabilitation and enhancement of anadromous fish habitat.

History of the Program

Organization and Planning.--In 1975, USDA Forest Service scientists, managers, and administrators from three Research Experiment Stations, five National Forest System Regions, and the National headquarters in Washington, D.C. developed a program for anadromous fish habitat research and management^{1/}. Input was received from several state and federal agencies, and from several universities. A document entitled "Proposed Anadromous Fish Habitat Program for the Western United States" (October, 1975) became the plan for USDA Forest Service anadromous fish habitat research during the period 1976-1980. The National Forest System and State and Private Forestry programs were outlined in this plan, but organizational and funding constraints precluded their contributing significantly to the Program during the period. The National Forest System did, however, maintain direct contact with and provide recommendations to the research efforts.

A planning document entitled "Progress Report (1976-1980) and Plans (1981 and 1985)" served to guide Forest Service anadromous fish habitat research and management through a second phase. Activity of the National

^{1/}Research

- Pacific Northwest Forest and Range Experiment Station
- Pacific Southwest Forest and Range Experiment Station
- Intermountain Forest and Range Experiment Station
- National Forest System
 - Region 1--Northern
 - Region 4--Intermountain
 - Region 5--Pacific Southwest
 - Region 6--Pacific Northwest
 - Region 10--Alaska

Forest System and other management agencies greatly increased during this period. The Salmon and Steelhead Habitat Opportunities Program was initiated. This program is an updated compilation of state-wide comprehensive plans developed in cooperation with State fish and wildlife agencies pursuant to the Sikes Act. This program will be implemented through the Forest Plans.

Coordination.--Beginning in 1977, program scientists, managers, and administrators, along with university cooperators and personnel from other federal and state agencies, have met annually or semiannually to discuss Program accomplishments and plans. These meetings have been effective in assuring that the objectives of the Program are being addressed.

Funding.--The plan for 1976-1980 called for a 5-year budget of \$8,275,000 for Research, \$13,820,000 for the National Forest System, and \$1,070,000 for State and Private Forestry for anadromous fish habitat protection and enhancement. From 1976 to 1980, the total anadromous fish habitat research funding was approximately \$3,200,000--less than half the funding required to complete the research outlined in the original plan. For 1981-1985, the plan called for \$8,008,000 for Research and \$37,350,000 for NFS. From 1981 to 1985, total funding was \$4,771,000 for anadromous fish research and \$7,235,000 for habitat protection and enhancement.

Program Participants

An important aspect of the Western Anadromous Fish Habitat Program is cooperation with other agencies and institutions as well as between the Research and the National Forest System branches of the USDA Forest Service. Following is a partial list of Research Program cooperators provided as an example of the diversity of organizations involved:

USDA Forest Service

- Tongass National Forest
- Chugach National Forest
- Willamette National Forest
- Wallowa-Whitman National Forest
- Siuslaw National Forest
- Siskiyou National Forest
- Ochoco National Forest
- Gifford Pinchot National Forest
- Mount Hood National Forest
- Olympic National Forest
- Clearwater National Forest
- NezPerce National Forest
- Salmon National Forest
- Boise National Forest
- Sawtooth National Forest
- Payette National Forest
- Challis National Forest
- Shasta-Trinity National Forest
- Six Rivers National Forest
- U.S. Fish and Wildlife Service
- National Fisheries Research Center
- Cooperative Fishery Research Units
- U.S. Environmental Protection Agency
- National Marine Fisheries Service
- National Park Service;
- Alaska Department of Fish and Game
- Oregon Department of Fish and Wildlife
- California Department of Fish and Game
- Idaho Department of Fish and Game
- University of Washington
- Montana State University
- Humboldt State University
- Case-Western Reserve University
- Fisheries Research Institute
- British Columbia Ministry of Environment
- Weyerhaeuser Company

Alaska Lumber and Pulp Company
Starkey Cattle and Horse Association
Bonneville Power Administration

A significant portion of the Program's research funding is used to support extramural research. The percentage varies from year to year, but averages 35 to 40 percent of available funding. Extramural research can provide specialized facilities and expertise to address specific research problems. With current limitations on funding and personnel ceilings, this way of doing research will continue to be an important part of the Program.

PROGRAM ELEMENTS

Accomplishments to Date

National Forest System.--Accomplishments fall into two categories, applications and development.

A. Applications.--Fisheries management support to other Forest activities such as timber harvest, road building, and range and energy development is an important element of the National Forest System program. Fisheries biologists conduct inventories and field investigations for planning timber sales, road construction, livestock grazing, energy and mineral development, and recreation development. Biologists participate in interdisciplinary planning teams, provide technical reports on environmental effects and opportunities, develop monitoring techniques and plans, and prepare timber sale area betterment (SAI) plans. These efforts minimize adverse impacts and maintain existing fish habitats.

Fisheries habitat improvement work, especially for anadromous fish, generally has a very favorable benefit/cost ratio and great public interest. Habitat capabilities, and consequently fish populations, are well below historic levels in many areas. It is estimated another 72 million pounds could be produced annually from National Forest System lands through an aggressive habitat improvement program that is both technically feasible and cost effective.

National Forests have made a good start towards implementing an increased anadromous fish habitat improvement program in the last 5 years. A major stimulus has been the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program funded through the Bonneville Power Administration. This program has provided nearly \$1 million a year in the last 2 years for projects primarily on National Forest lands in Washington, Oregon, and Idaho. Additional funding was provided by Congress in Fiscal Year 1985 to start implementation of the Forest Service's Salmon and Steelhead Habitat Opportunities Initiative.

National Forest personnel have worked closely with Research to develop better and more efficient methods to improve habitat. National Forest System and Research personnel are also cooperating in the evaluation of models being used, such as the Region 1/Region 4 Sediment Fish Response Model developed and published in 1983 by the Northern and Intermountain Regions.

B. Development.--Development activities from 1980-1985 were focused in four major areas (see below).

1. Land/Aquatic Classification and Channel Typing. The Wildlife and Fish Ecology Unit, assisted by the Intermountain Station, developed procedures to classify aquatic habitats as a basis for developing fish production models. Four Forests in two anadromous fish-producing Regions have started tests of the classification system and have begun data collection for model development. These tests are not yet complete and investigators are evaluating channel typing as a further classification criterion.

2. Inventory Methods.--A review of models that predict standing crop of stream fish was completed by the USDA Forest Service Wildlife and Fish Ecology Unit, and Colorado State University, to identify a core set of physical measurements that should be collected during inventories. Following consultation with the PNW and INT Research Stations, a field inventory procedure was developed that defined standard methods and terminology. This procedure has been provided to the Habitat Inventory Committee, Western Division, American Fisheries Society for their review and possible adoption.

3. Fish Habitat Relationships Models.--Several models have been developed conceptually and are in various stages of evaluation and refinement. A fish response to sediment model (FISHSED) has been developed jointly by National Forest fishery biologists in Regions 1 and 4, the Intermountain Forest and Range Experiment Station, and the University of Idaho. This model has been applied at forest planning and project levels, in conjunction with the Region 1/Region 4 sediment model. Cumulative effects evaluation has been accomplished on two Forests using these models.

A model simulating fish response to use of riparian areas by livestock (COWFISH) has been developed jointly by Region 1 fishery and management personnel and the Intermountain Forest and Range Experiment Station and has been applied at forest planning and project levels. This model is being adapted for use in other Regions and will undergo further evaluation and refinement.

A smolt habitat-capability-index model to predict anadromous fish production for Forest Planning has been developed jointly by Region 6 and PNW fisheries personnel. Regions 5 and 10 are evaluating the potential of adapting the model for their use.

The Southeast Alaska multi-resource model has been developed and is being evaluated on a timber sale. A subsidiary fish habitat model that determines the relationship between large woody debris and fish biomass is under development by Region 10 fisheries personnel, the Pacific Northwest Forest and Range Experiment Station, and the Alaska Department of Fish and Game.

4. Monitoring.--Region 6 fisheries biologists and PNW scientists have developed monitoring procedures to maximize effectiveness of habitat improvement techniques. These procedures and concepts are being perceived as valuable assessment tools by other Regions.

Research.--Anadromous fish habitat research is conducted in three Research Work Units at four major locations--Juneau, Alaska; Corvallis, Oregon; Arcata, California; and Boise, Idaho. Research at Juneau and Corvallis focuses on biological relationships of anadromous salmonids to forest-based land uses. Work at Boise highlights the relationship of fish habitat to rangeland grazing, while studies at Arcata feature geomorphic processes of habitat formation and change.

During the last 5 years, significant progress has been made in understanding the functional relationships fish have with their stream environment and impacts of land use on fish habitat. Major efforts were

made to provide newly acquired technology to planners and managers, even before formal results were published. Work during 1981-1985 has produced more than 130 publications in scientific journals, Forest Service and other agency technical papers, symposium proceedings, and other outlets. Details of this effort cannot be given here. (See appendix I for list of publications.) However, the following highlights are presented to characterize the nature of the accomplishments. Highlights of accomplishments are annotated under the same two major categories of research provided in the 1981-1985 Plan--Resource Planning and Resource Management.

A. Resource Planning.--

1. Habitat Requirements.--

a. Large Woody Debris (LWD). Habitat management guidelines have long recommended removal of logging slash and debris from streams to facilitate passage of anadromous fish. Enthusiasm for this program resulted in removal of much naturally-occurring LWD as well. However, research has shown that LWD is essential to habitat and provides necessary structure for pool formation, habitat diversity, and cover. In addition, LWD provides an important source of nutrients vital to maintaining a productive aquatic system. Indeed, the importance of LWD to rearing salmonids extends to the margins and flood plains of large streams. Without ample LWD, rearing habitat for salmonids can be diminished; likewise habitat can be improved by adding LWD. Guidelines for management of LWD have been transferred to users.

b. Streamside Vegetation. In addition to providing LWD to streams, riparian vegetation also furnishes insect food and cover for rearing salmonids, provides bank stability and shade to maintain cool water temperatures, and helps control sedimentation.

c. Coho Salmon. The importance of off-channel rearing areas (e.g. beaver ponds, sloughs, side channels) for coho salmon has been demonstrated in Oregon and Alaska. In fact, beaver ponds with their nutrient-rich waters are an important ecological feature of rearing habitat for coho. The ponds release nutrients for enhancing productivity of down-stream rearing areas as well. In Alaska, research has demonstrated that quality winter habitats of coho salmon characteristically can be found where mature riparian vegetation has been little disturbed by man. Degraded winter habitat can limit production by causing higher mortality and premature downstream movement of pre-smolts.

d. Techniques. Important progress was made in development of quantitative techniques applicable to habitat assessment for both research and management. Particularly noteworthy are the key breakthroughs made in methods for analyzing spawning gravels, which have opened up new horizons for study of relationships at the microhabitat level. Included are the development of a freeze-core gravel sampling technique and a state-of-the-art instrument to measure intragravel water velocity. A portable and highly efficient device for marking juvenile salmonids with a freeze-brand was developed to assess fish population levels, movement, and

microhabitat use. In addition, a non-destructive method for removing stomach contents for salmonid food-habits studies was developed, and a digital light integrator was developed to assess effects of riparian management on stream shading and temperatures.

2. Natural Processes.--

a. Sedimentation. In northern California research has identified physical factors and processes influencing infiltration of fine sediments into spawning gravels. Fine sand and silt threaten spawning success. In sediment-rich streams of northern California, infiltration rates can be so high that successful spawning can require periodic scour and fill of gravel beds. However, scour and fill also introduce large concentrations of fine sand and frequently wash eggs from the gravel, or bury them. Spawning success depends in part on the timing of moderate to large flow events and selection by fish of spawning sites.

b. Catastrophic Events. Periodic flooding can have major effects on anadromous salmonid habitat. Studies in northern California have provided an understanding of the mechanisms, rates, and form of recovery of such degraded habitat. Eruption of Mount St. Helens provided a unique opportunity to study both the physical and biological impacts and processes of recovery within the blast and ash-fall zones. These studies have produced information useful in assessing effects of catastrophic sedimentation and debris events on streams and lakes.

c. Stream Structure. Research results from all locations continue to emphasize the importance of stream structure. Work in northern California has defined the general effects of structure on channel form and stability and established geomorphic factors influencing formation of spawning and rearing habitat.

3. Land Use Relationships.--

a. Temperature. An important study determined the role of temperature on competitive interactions for habitat between redbreasted shiners and steelhead trout. Results showed that a few degrees increase in temperature can tip the ecological balance in favor of shiner production at the expense of steelhead trout. Other research has quantified the effects of winter temperature on the development rate and mortality of coho salmon and steelhead trout.

b. Sediment. Studies have been carried out to determine the effects of chronic turbidity on feeding and growth of juvenile steelhead trout and coho salmon. Survival and growth of fry were reduced at levels of turbidity commonly produced by managed lands during a series of spring storm events. Research scientists and managers used this and other published and unpublished information to develop a preliminary guide for predicting salmonid response to sediment yield.

c. Debris Torrents. Studies have been conducted to determine the relationship of debris torrents to fish habitat. Results were used to develop a risk rating system to assess the potential effects of debris torrents on salmonid habitats.

4. Inventory and Classification of Habitat.--In response to the need of both managers and researchers, scientists have developed a methodology for evaluating stream and riparian conditions, which standardizes the way physical and biological attributes are measured and quantified.

Research scientists working closely with managers have hypothesized an aquatic classification system, which is currently under study. The system uses geographic, geomorphic, climatic, and other variables to group streams and habitats with similar physical and biological characteristics.

5. Economic Analyses.--Management decisions are hindered because the value of fish habitat is not adequately stated in economic terms. Current studies are addressing benefits and costs of various habitat improvement technologies.

6. Synthesis of Existing Knowledge.--Among the many syntheses of literature completed during the last 5 years, the most noteworthy is completion of the 14 part compendium series: "Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America."

Other noteworthy products include a synthesis of information on relationships of forest management to anadromous fish habitat in western Oregon and Washington, and a summary of the relationships between forest management, fine sediment, and salmonid production.

B. Resource Management.

1. Evaluation of Land Use Effects.--

a. Timber Harvest and Roads. Significant progress has been made in understanding the physical behavior of debris flows originating from clearcuts and roads, and their effects on habitat of anadromous salmonids. Models have been developed that predict how far debris flows will travel from the point of origin, where deposition will occur, and how migrations and rearing habitat of salmonids will be affected. The models have been successfully tested in two different geologic regions in western Oregon.

b. Livestock Grazing. A major effort has been underway during 1981-1985 to determine the consequence of various riparian grazing strategies on anadromous fish habitat. Most of this work has been conducted out of the Boise, Idaho, location. Studies have defined the degree of aquatic and riparian habitat alteration for alternative levels of herbage utilization under different rotation systems and between grazing by sheep and grazing by cattle. For example, results showed that a rest-rotation sheep grazing strategy with good herding and favorable stocking had undetectable impacts on riparian-stream habitats. For grazing by cattle, a special riparian pasture set aside within a large allotment, and including a mixture of both upland and riparian vegetation, shows promise as a way of providing a balance of upland and riparian areas for livestock without unacceptable impacts on streamside vegetation or streambanks vital to healthy fish habitat.

2. Habitat Enhancement.--

a. Development of Enhancement Methods. Findings on the relationship of coho salmon to natural beaver ponds has led to development of a technique for creating artificial beaver ponds on riparian flats adjacent to streams. Studies have shown that artificial beaver ponds have effects similar to naturally occurring ones. The production of coho salmon was increased by 18 percent on one study stream with the installation of a single artificial beaver pond.

b. Evaluation of Habitat Enhancement. Extensive evaluation of existing habitat enhancement methods is currently in progress. Cooperative studies in Idaho, California, Oregon, and Alaska are evaluating both stream channel and off-channel improvement techniques.

3. Funding. Forest Service anadromous fish habitat research is supported primarily from annual appropriations out of the Wildlife, Range, and Fisheries Habitat Research (WRFHR) budget line item. In 1985, this amounted to \$1,014,000 out of the total of \$8,876,000 (11%) for all wildlife, range, and fish habitat research nationwide. The appropriation was divided between three Research Work Units. The Bonneville Power Administration, Tongass Timber Supply Fund, Bureau of Land Management, National Park Service, and California Fish and Game have provided additional support.

With the exception of Fiscal Year 1981, appropriated funding has not met projected needs as outlined in the 1981-1985 research plan for the Anadromous Fish Habitat Program (Table 3). Funds provided by

other agencies have in part mitigated this impact, but appropriated funds for Fiscal Years 1982 to 1985 provided a decreasing proportion.

Table 3. Comparison of funding (\$1,000's) needs to accomplish the FY 1981-1985 Western Anadromous Fish Habitat Research Program and appropriated funds to accomplish the program plan.

Fiscal year	1981-1985 Program needs	Appropriated funding
1981	927	993
1982	1,527	1,076
1983	1,527	902
1984	1,527	768
1985	2,500	1,014

PLANS FOR THE FUTURE (1986-1990)

Application

During the next five years, the National Forest System will continue to emphasize cost-effective anadromous fish habitat improvement and a high level of resource coordination in support of the National Forest System goal to improve habitat carrying capacity of anadromous salmonids. The result will be increased production of anadromous fish for commercial and sport fishing, Native American subsistence and ceremonial use, and compensation for losses from other resource development activities.

The major anadromous fish restoration, enhancement, and maintenance activities are included in the Salmon and Steelhead Habitat Opportunities Program. The program is a compilation of Forest Plans and State Sikes Act Plan activities and includes an assessment of probable benefits to user groups. The projected 1986-90 funding and resulting predicted fish production increases from this program are listed in Table 4.

Development

Emphasis during the 1986-1990 period will shift from National development to Regional programs incorporating identifiable goals, measureable objectives, schedules for action, and links to the budgeting process. At present, there is a need for accomplishment accountability

Table 4. Projected appropriated funding needed (1986-1990) for National Forest System anadromous fish habitat maintenance, restoration, and enhancement, and predicted increases in fish production* from the Program.

State	1986		1987		1988		1989		1990		Total	
	Cost (K\$)	Harvest	Cost (K\$)	Harvest	Cost (K\$)	Harvest	Cost (K\$)	Harvest	Cost (K\$)	Harvest	Cost (K\$)	Harvest
Alaska	4,100	330,000	5,300	420,000	6,400	510,000	7,100	540,000	7,500	562,000	30,400	2,362,000
Oregon and Washington	1,900	37,900	3,100	84,900	2,900	95,100	3,600	105,900	4,000	115,600	15,000	439,100
Idaho	662	10,700	834	27,400	1,021	54,600	1,072	82,900	1,072	82,900	4,661	258,500
Northern California	839	23,200	850	20,400	1,327	36,400	1,322	39,200	1,424	34,500	5,762	153,700
Michigan	240	30,000	360	45,000	235	30,000	235	30,000	243	32,700	1,313	167,700

*Increase in average number of salmon and steelhead available for harvest for the duration of the projects (average 15 years).

Note: (K\$) refers to thousands of dollars.

FY 1984 and 1985 program levels were \$3.8 million.

FY 1986 program is funded at \$3.6 million (50% of projected need).

at all administrative levels. Greater management emphasis, a more active leadership role by Regional Fish and Wildlife Directors, and better links to research will be critical to the success of the development program.

Several specific actions will be initiated including:

1. Obtaining more expert Regional staffing to broadly implement the development program.
2. Increasing investment to complete development work at Regional Offices and field locations.
3. Forming a group of researchers and Forest personnel to develop cumulative effects and risk analysis procedures for field application.
4. Completing development and application of a land/aquatic classification system in cooperation with other National Forest disciplines and research personnel.

Much of the work cited above is directly related to the National Forest System Fish Habitat Relationships Program and its links with research. The funding needed in the anadromous fish Regions to accomplish these and ongoing tasks is as follows:

	Years				
	1986	1987	1988	1989	1990
Dollars (M)*	402	445	445	445	445

*(Combined for Regions 1, 4, 5, 6, and 10.)

Research

Unmet needs.--There are many unmet needs for research to address during the next five years. The highest priority subject areas are listed below.

A. Habitat Requirements and Limiting Factors.--Predictive relationships can be established only if habitat requirements of anadromous salmonids are thoroughly known. Although research has established general spawning, rearing, and migration requirements, the quantitative limits of these requirements, as well as the differences in requirements, of a given species from one part of its range to another are still largely unknown.

For example, more study needs to be done on the northern races of chinook salmon and other species whose life requirements are not as completely known as those of coho salmon and steelhead. Fish embryo survival as related to intragravel conditions and rearing habitat requirements with respect to seasonal conditions and the kinds, distribution, and balance of habitats within a stream system need to be studied. Research on habitat requirements has centered on southeast Alaska, the Pacific Northwest and the Intermountain region. Because conditions vary regionally and the response of fish to these habitat conditions is not known, research needs to be expanded geographically. In Alaska, work should be initiated on the Copper River Delta, and additional work is needed in northwest Washington. Research to link biological requirements with geomorphic processes of habitat formation is a high priority in northern California. In Idaho, research needs to be

initiated that will link biological requirements of anadromous salmonids with riparian habitat types, aquatic habitat types, and the condition of each.

B. Natural Processes.--Even in undisturbed conditions, habitat of anadromous salmonids is dynamic and strongly influenced by physical processes. Research in northern California has made a pioneering contribution to the understanding of physical processes of habitat dynamics under natural and man-induced perturbations. However, in order to predict the outcome of land management on habitat, and design habitat improvements, considerable additional research should be undertaken. In particular, studies need to address the role of stream structures (organic debris, logs, rocks and boulders, and gabions) in creating pool habitat conditions favorable for juvenile anadromous salmonids. Studies of whole watersheds need to be initiated to identify modes and processes of sediment transport and effects of sediment loads on channel morphology under varying watershed characteristics and treatments.

C. Land-Use Relationships and Effects.--Direct study of the relationships of fish and fish habitat to, and effects of, various land uses is essential. The type and amount of riparian vegetation in watersheds is critical in determining the quality of fish habitat. Studies need to address the nature of the relationship of riparian-overstory vegetation to such factors as stream habitat structure and water temperature. Research needs to evaluate the effects of road construction and timber management on fish habitat, including study of cumulative effects and changes in fish habitat over a stand rotation.

Because sediment generated by land uses can affect fish habitat in a major way, basic factors controlling the response of fish to sedimentation need to be identified and quantified.

In the Intermountain West, grazing by livestock on riparian areas significantly influences anadromous salmonid habitat. Long term study of the suitability of various grazing systems needs to continue, with emphasis on testing various strategies to integrate grazing of uplands with that of riparian areas. However, more fundamental study of relationships of grazing to the physical and biotic response of riparian-stream habitat is basic to development of a quantitative model for predicting response of fish habitat to grazing.

D. Habitat Enhancement.--Construction of hydroelectric impoundments and power plants, other land uses, and heavy commercial exploitation of anadromous fish has resulted in reduced returns of adult fish. Because of this, maintenance of remaining high quality spawning and rearing habitat is critical. Among the most important research tasks is to find ways to not only mitigate negative effects of land-use but also to find ways to improve habitat. Existing in-stream habitat improvement methods must be evaluated and new cost-effective methods of habitat enhancement need to be developed on the basis of other research findings. Techniques to rehabilitate riparian zones are critically needed. In forested areas, finding ways to control the amount, distribution, and timing of large woody debris entering streams is essential to long-term stream productivity. In addition, economic studies need to examine benefits and costs of management so that anadromous fish habitat planning and management can be stated in terms comparable with other resource outputs.

E. Inventory and Classification.--Research is needed to develop methods of inventory. The National Forest Management Act and pursuant regulations mandate monitoring of management indicator species. Concepts, systems, and methods of monitoring should be developed to assess response to management at both project and forest-wide levels of management. Included in this work should be: (1) testing of existing inventory methods, (2) development of new concepts, methods, and systems of monitoring, (3) development of concepts and methods of quantifying habitat quality, and (4) determination of nonhabitat-related factors influencing population levels.

Related research also needs to refine and expand existing systems of fishery classification. A holistic approach is needed to tie aquatic-riparian systems to fishery classification. Basic to this research is an understanding of the structural and functional relationships of riparian-stream systems.

Current Program Plan.--Table 5 displays details of the plans for the current program, and an expanded program, by annual funding in each of several research components. The research components address unmet needs highlighted in the previous discussion. Funding specified for the program levels detailed in Table 5 reflect research priorities, with highest-priority work represented by the planned current program, which is expressed in Fiscal Year 1985 appropriated funding levels.

The planned research program features a greater emphasis on land-use relationships and habitat enhancement studies in Idaho, Alaska and the

Pacific Northwest than during the previous five years. Studies of habitat requirements in this region will focus on juveniles, while the recently developed intragravel flow meter will permit quantification of microhabitat aspects of embryo survival. Extramural funds from the Bonneville Power Administration have permitted a greatly expanded effort in the evaluation of habitat enhancement methods. Further investigation to refine our understanding of the relationship of woody debris to fish habitat will still be featured prominently in studies of land-use relationships.

Importantly, a modest increase in funding for Fiscal Year 1985 programs in northern California and the Intermountain West has allowed expansion and acceleration of studies. A small biological program was initiated in California to link closely with ongoing research on geomorphic processes of habitat formation. Closely coordinated studies of fish habitat use and physical processes of habitat development will pay large future dividends in the ability to project relationships to land use and management of fish habitat.

Table 5. Western Anadromous Fish Program research plans for 1986-1990 showing needed annual appropriation levels of funding (\$1,000) to address research plan components at the current and expanded program levels.

Research Component	Current Program Plan	Expanded program funding priorities	
		1	2
Habitat Requirements and Limiting Factors:			
Fish embryo survival as related to intragravel conditions.	100	100	100
Rearing habitat requirements with respect to winter conditions, off-channel areas, and beaver dams.	137	187	187
Micro- and macro-habitat use selection and partitioning among species of juve- nile salmonids.	60	60	60
Habitat quality and productivity as related to availability and balance among habitat types in whole drainage systems.	30	100	100
Relationships of cobble embeddedness and sedimentation to habitat selection; effects of bed instability on fish.	<u>0</u>	<u>100</u>	<u>150</u>
Total Habitat Requirements	327	547	597

Research Component	Current Program Plan	Expanded program funding priorities	
		1	2
Natural Processes:			
Role of structure in (and fish response to)habitat formation, with emphasis on largewoody debris; factors, and processes of "cold pool" formation.	88	88	88
Modes of sediment introduction and transport through drainage systems and its effect on fish habitat.	0	75	75
Effects of sediment load on channel morphology under different conditions of channel gradients valley configurations, and channel structure.	<u>0</u>	<u>75</u>	<u>75</u>
Total Natural Processes	88	238	238
Inventory and Classification:			
Structural and functional inter-relationships of forest and range riparian stream systems for development of a comprehensive riparian land-aquatic classification system.	30	85	110
Development of cost-effective system/methods of evaluation of habitat quality and monitoring fish response to management activities.	<u>10</u>	<u>75</u>	<u>75</u>
Total Inventory and Classification	40	160	235

Table 5. (Continued)

Research Component	Current Program Plan	Expanded program funding priorities	
		1	2
Land-use Relationships and Effects:			
Relationships of riparian vegetation to large woody debris, water temperature, habitat structure, fish survival, reproductive success and the quality of beaver pond habitat.	143	143	143
Basic factors controlling the response and productivity of fish to sedimentation; development of a model for predicting response of fish to sedimentation.	60	90	140
Suitability of existing grazing management methods for riparian-stream habitats; relationship of timing, intensity, and duration of livestock grazing to physical and biotic response of habitat; development of new grazing methods and a model for predicting response of fish habitat to grazing.	72	220	247
Evaluation of the effects of road construction, timber harvesting, and timber management systems on fish habitat, including study of cumulative effects and changes on fish habitat over a stand rotation.	10	100	144
Total Land-use Relationships and Effects	285	555	674

Table 5. (Continued)

Research Component	Current Program Plan	Expanded program funding priorities	
		1	2
Habitat Enhancement:			
Evaluation of existing stream habitat improvement techniques and development of new habitat improvement methods.	150	150	200
Development of reliable, cost-effective forest and rangeland riparian rehabilitation methods.	37	77	100
Development of streamside management techniques to control the amount, distribution, and timing of large woody debris entering streams.	<u>0</u>	<u>100</u>	<u>100</u>
Total Habitat Enhancement	187	327	400
Economic Analysis:			
Economics of alternative riparian-grazing methods and rehabilitation measures.	50	50	50
Economic analysis of alternative stream improvement methods.	<u>37</u>	<u>37</u>	<u>70</u>
Total Economic Analyses	87	87	120
<hr/>			
PROGRAM TOTAL	1014	1914	2264

In the Intermountain West, a new research work unit has been formed and chartered to expand and accelerate studies of grazing-fish relationships and to integrate these studies with those of riparian wildlife, economics, and riparian rehabilitation. Importantly, work also will be initiated on testing and refinement of the previously postulated model of fish responses to sedimentation.

Expanded Program Plan.--The expanded program, given at two alternative levels of funding (Table 5), is consistent with the Forest Service national program plan documented in "Meeting the Challenges--A Program in Wildlife and Fish Habitat Research" (prepared by Forest Environment Research, USDA Forest Service, December 1, 1984). Although the Expanded Program features a doubling of the current Program, not all research needs could be addressed in the plan. The relationship of anadromous fish habitat to mining has not been included; study of direct effects of forest management would be at a minimum; and economic studies would only continue at the base-level of funding provided in the current program.

The Expanded Program would permit a greatly needed intensification of research on habitat relationships in northern California, which would be tied closely to additional research on physical processes of fish habitat formation. This research would be integrated with studies of modes of sediment introduction and other watershed processes being conducted by watershed management researchers.

The Expanded Program would accelerate research on stream-riparian ecosystem structure and function, and develop a related riparian-fishery classification system. Significant studies on methods and systems for evaluating fish habitat quality and monitoring could be initiated.

The Expanded Program also would permit expansion of research on fish habitat-livestock interactions and predict the outcome of the timing, intensity, and duration of livestock grazing on fish habitat. Similarly, research could address more directly the effects of road construction, various timber management systems, cumulative effects, and the relationship of habitat to stand development over time. Study of in-stream habitat improvement methods and rangeland stream-riparian rehabilitation methods would be accelerated, and critical investigations to develop ways of managing riparian overstory in forested areas could be initiated.

APPENDIX I
WESTERN ANADROMOUS FISH HABITAT PROGRAM
PUBLICATION RECORD
RESEARCH

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